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# Laser Safety at LIGO

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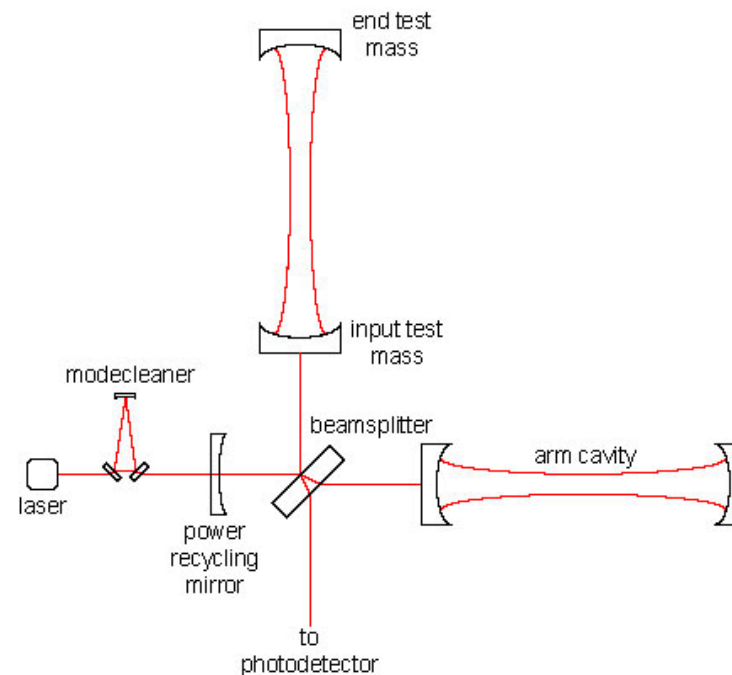
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# What Is The LIGO Project?

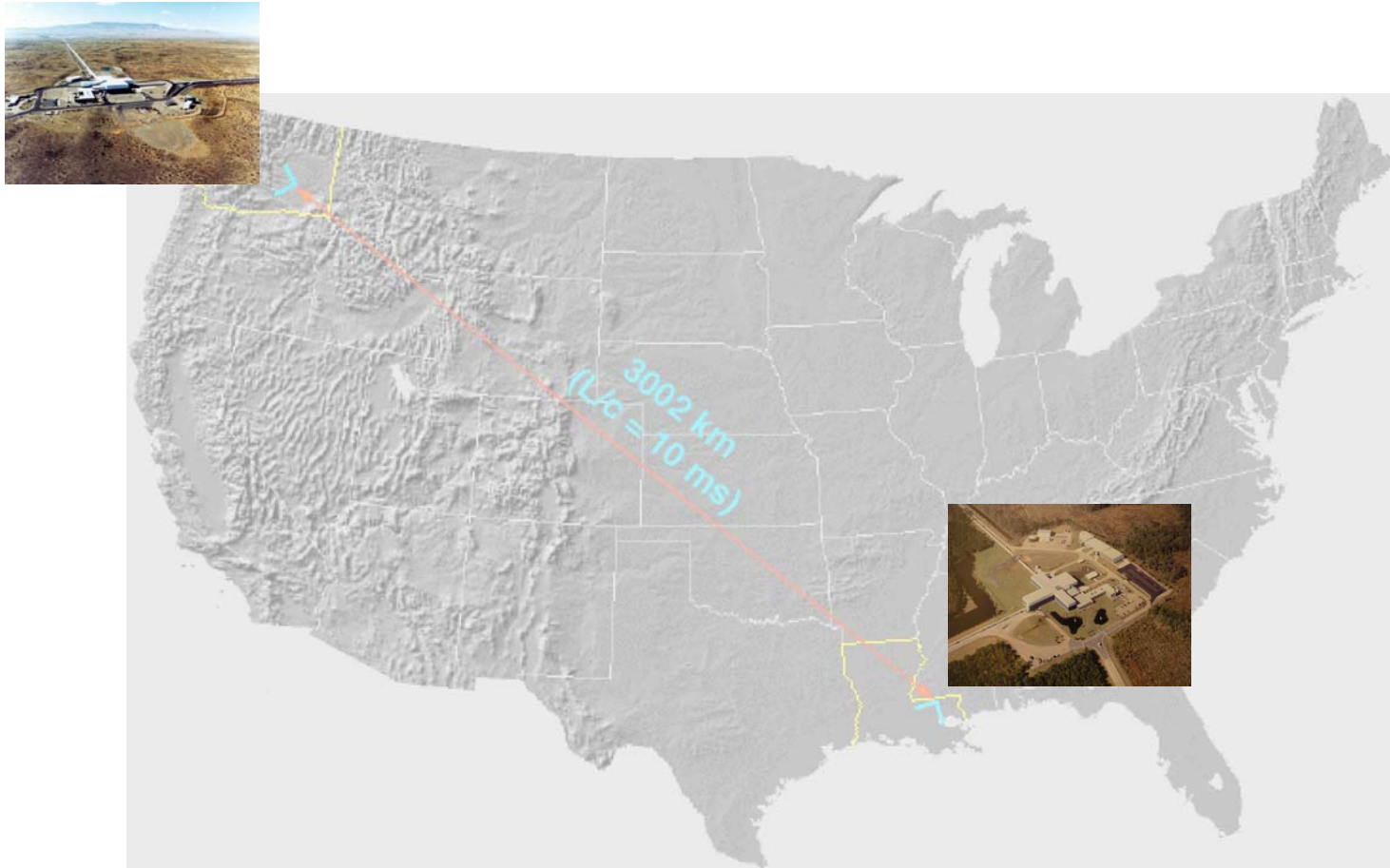
- LIGO is the **L**aser **I**nterferometer **G**ravitational-wave **O**bservatory
  - » A Michelson interferometer with 4 km long Fabry-Perot arms





# What is the LIGO Project? (cont.)

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# Lasers at LIGO

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- A number of lasers are present at the observatories, the major ones are:

- » Nd:YAG operating at 1064 nm — the pre-stabilised laser
- » CO<sub>2</sub> operating at 10.6  $\mu$ m — the thermal compensation system
- » HeNe operating at 633 nm — optical levers

All operate simultaneously, which complicates selection of laser safety eyewear

- Multiple wavelengths

- » Visible to far infrared

- Wide range of laser power

- » ~ a few mW (visible) to tens of watts (near and far infrared)



# Laser Safety Practices and Implementation

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- Two operational states defined:  
    **LASER SAFE**  
    and  
    **LASER HAZARD**
- All optical tables are enclosed



# Practices and Implementation

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- Three levels of user
  - » laser system sponsor
  - » registered laser personnel
  - » basic trained personnel
- Access to tables is restricted both procedurally and by use of an access control system
- Swipe cards to access tables and laser areas
  - » Each authorised user has their own card.
  - » Cards issued only by the LSO.





# Practices and Implementation (cont.)

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- All activities involving card reader entries and exits, door openings and closings are recorded and time stamped
  - » All are recorded and displayed in the Control Room
  - » Violations trigger an alarm (visible and audible) in the Control Room
  - » Events causing an alarm include
    - forced doors
    - doors not properly closed
    - invalid card
- The violation must be corrected or the system will not reset.



# Practices and Implementation (cont.)

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- Emergency stop buttons are located near all Class 3B and Class 4 lasers
  - » Activating the emergency stop, kills all Class 3B and Class 4 lasers in the same building
  - » Resetting the emergency stop does not automatically restore power to the laser power supply.
    - Requires manual activation of a power reset
- All laser power supplies are connected to dedicated power circuits.
  - » Power circuits are only energised when the warning light is activated.
- Training of personnel by the laser system sponsor





# Practices and Implementation (cont.)

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- Changes to optical tables are noted and logged
- IR viewer scans of optical tables are conducted on a ~weekly basis
- Incident threshold of  $100 \mu\text{W}$ 
  - » Incidents require a shutdown of the laser and an incident report
  - » Approval to restore laser only given by the LIGO Directorate



# Special Requirements

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- All main optics are either super-polished or laser grade for minimal scatter
  - » Helps reduce scattered light
- Low back scatter beam dumps
  - » Commercial beam dumps have too much back scatter — a noise source for the interferometer

# Evaluation of Laser Safety Equipment

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- Conducted tests of laser safety eyewear
- Problems encountered with polycarbonate laser safety eyewear
  - » Possible coating defect?
  - » Incorrect cleaning solvent?



# Non-laser Hazards at LIGO

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- Traffic hazards



- Wildlife





# Towards the Future

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- Advanced LIGO, an upgrade to the LIGO detector
  - » 200-W Nd:YAG laser
  - » Higher power CO<sub>2</sub> laser
- Laser safety policies are being revised
- Revised incident level threshold
- Scattered light verification

## Acknowledgement

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